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Original article

Agreement between physical therapists and radiologists of stratifying patients with shoulder pain into new treatment related categories using ultrasound; an exploratory study

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A B S T R A C T

Study design: A systematic overview of the literature and an agreement study.
Objectives: The aim of this study is to explore the inter-professional agreement of diagnostic musculoskeletal ultrasound (DMUS) between physical therapists (PT) and radiologists, using a new classification strategy based upon the therapeutic consequences in patients with shoulder pain.
Background: DMUS is frequently used by PTs, although the agreement regarding traditional diagnostic labels between PTs and radiologists is only fair. Nevertheless, DMUS could be useful when used as a stratifying-tool.
Methods: First, a systematic overview of current evidence was performed to assess which traditional diagnostic labels could be recoded into new treatment related categories (referral to secondary care, corticosteroid injections, physical therapy, watchful waiting). Next, kappa values were calculated for these categories between PTs and radiologists.
Results: Only three categories were extracted, as none of the traditional diagnostic labels were classified into the 'corticosteroid injection' category. Overall, we found moderate agreement to stratify patients into treatment related categories and substantial agreement for the category 'referral to secondary care'. Both categories 'watchful waiting' and 'indication for physical therapy' showed moderate agreement between the two professions.
Conclusion: Our results indicate that the agreement between radiologists and PTs is moderate to substantial when labelling is based on treatment consequences. DMUS might be able to help the PT to guide treatment, especially for the category 'referral to secondary care' as this showed the highest agreement. However, as this is just an explorative study, more research is needed, to validate and assess the consequences of this stratification classification for clinical care.

1. Introduction

Shoulder pain presents an economic burden on society due to costs for sick leave and health care (Huisstede et al., 2006). A high number of patients visit a general practitioner (GP) (Greving et al., 2012). A large amount of people who have shoulder pain, visit a physical therapist (PT) at some point (Linsell et al., 2006). The prognosis, however, is moderate, as only 60% of patients recover within six months after consulting a PT (Karel et al., 2016).

The classic clinical pathway of PTs for patients presenting with shoulder pain includes history taking and physical examination, which eventually leads to a physiotherapeutic diagnosis and management plan. However, physical examination is often inadequate for establishing a diagnosis, as it lacks validity and reproducibility (Beaudreuil et al., 2009; Hegedus et al., 2008; Hughes et al., 2008). To overcome this flaw, diagnostic musculoskeletal ultrasonography (DMUS) is increasingly used by PTs in order to improve their diagnostics (McKiernan et al., 2010). The majority of PTs using DMUS indicate they expect

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DMUS to facilitate them in making a more specific clinical diagnosis or assist them in selecting the most appropriate intervention (Karel et al., 2017). However, an inter-professional agreement study showed only fair agreement of DMUS between PTs and radiologists (with an overall kappa of 0.36; varying from a kappa of 0.10 for partial thickness tears to 0.63 for full thickness tears) (Thoomes-de Graaf et al., 2014).

Traditional diagnostic labels of the shoulder (such as subacromial bursitis) have not shown to be of much additional value in clinical practice or research so far. Moreover, the Dutch guideline for shoulder pain issued by the Dutch Orthopaedic Association stated that a direct relationship between the anatomical substrate, functional loading and pain is not always explicitly present and therefore, the diagnostic term 'subacromial impingement' is incorrect (Diercks et al., 2014). A more pragmatic approach was suggested over a decade ago (Schellingerhout et al., 2008), consisting of: "'general shoulder pain' or subgroups with a better prognosis and/or treatment result based on common characteristics that are easily and validly reproducible" (Schellingerhout et al., 2008), hereby linking a diagnostic label to a specific prognosis and/or an effective treatment category. This would be in concordance with the promising approach of classifying patients with low back pain and/or neck pain based on their prognosis, for example using the STarT Back Tool (Bier et al., 2017; Hill et al., 2011; Koes et al., 2010).

Ideally, when classifying patients, consideration is also given to biopsychosocial factors affecting prognosis. However, a generic musculoskeletal prognostic tool including these factors is not yet available. Currently, in patients with shoulder pain PTs mainly focus on pain and function (Campbell, 2016). As the prognosis of patients with shoulder pain is not particularly favorable, it is likely the patient will see several health care professionals for his/her shoulder pain. It can be frustrating and confusing if a patient receives different diagnostic labels from the various health care professionals such as 'tendinitis' or 'impingement', as diagnostic terms have implications on patients' perceptions. Therefore, this should be considered when using these different diagnostic terms. It may be in the best interest of the patient and PT to refrain from using these traditional labels and use labels that give direction to the treatment process.

Differentiating between subgroups relevant to a specific treatment, immediately impacts the therapeutic process (Lord et al., 2011). The Dutch guideline for GPs states physical therapy, corticosteroid injections and surgery are widely used treatment modalities, and besides 'watchful waiting', are advised in patients with various shoulder disorders (Winters et al., 2008). It is important to match these four treatment modalities with diagnostic labels based on evidence of effectiveness. DMUS potentially can be used to stratify patients into different treatment approaches.

The main aim of this paper is to explore a clinical pathway, by stratifying shoulder patients based on DMUS using a new classification strategy based on treatment effectiveness. As this is an explorative paper, the aims of this study are threefold:

1) To conduct a systemic overview of current evidence on the effectiveness of 'surgery', 'corticosteroid injection', 'physical therapy' and 'watchful waiting' for traditional diagnostic labels, in order to establish a new classification strategy of treatment related categories
2) To use the findings from DMUS to stratify patients into the new treatment related categories (resulting from aim 1);
3) To establish the agreement between PTs and radiologists of stratifying patients with shoulder pain into the new treatment related categories (resulting from aim 2).

2. Methods

2.1. Design

This study consists of two parts: First a systematic overview of current evidence was conducted to establish new treatment related categories, that was followed by an inter-professional agreement study. To conduct the agreement study data were used of our prognostic cohort study: 'Shoulder Complaints and Diagnostic Ultrasound in Physiotherapy' (ShoCoDiP) (Karel et al., 2013).

2.2. Systematic overview of current evidence

2.2.1. Search

A research librarian, together with an author (MTG) developed the search strategy and performed the electronic search (EMBASE and the Cochrane Library) from inception to January 2017. The search primarily focussed on systematic reviews of treatment effectiveness for patients with shoulder pain using traditional diagnostic labels. If no systematic reviews were found for one or more traditional diagnostic labels, a wider search was performed aimed at other types of studies.

2.2.2. Study selection

We selected systematic reviews describing the effectiveness of surgery, corticosteroid injections, physical therapy and/or watchful waiting in patients with various shoulder disorders. We searched for the traditional diagnostic labels (e.g. full- and partial thickness tears, tendinopathy, calcification of the rotator cuff, bursitis, SLAP lesions) as well as their collective synonyms (e.g. rotator cuff disorders, subacromial pain, impingement syndrome). In the absence of systematic reviews for one or more traditional diagnostic labels other types of research were included.

2.2.3. Data extraction, risk of bias assessment and analysis

Two of the authors (MTG, RO) independently extracted data and the conclusions from these articles. Systematic reviews were assessed on their Risk of Bias by two authors (MTG, RO) using the AMSTAR 2 (Shea et al., 2017). The AMSTAR 2 consists of 16 items and results in an overall rating of confidence in the results of the review (high, moderate, low or critically low) (Shea et al., 2017). Other risk of bias tools were used if applicable. In case of discussion a third author (AV) was consulted. For assigning a level of evidence we used the Center of Evidence Based Medicine classification (Howick et al., 2011). Relevant items are described below:

- Level 1: Systematic review*
- Level 2: Randomized Clinical Trial (RCT) or inception cohort study
- Level 3: Non-randomized control study or cohort study
- Level 4: Case series or case-control study
- Level 5: Mechanism based reasoning or expert opinion

* In case the results of the AMSTAR 2 classification were low or critically low the evidence was downgraded.

Two authors (MTG, RO) independently classified the traditional labels into new treatment related categories based upon the available evidence of effectiveness of 'surgery', 'corticosteroid injections', 'physical therapy' and 'watchful waiting' per traditional diagnostic label:

- 'Referral to secondary care' for patients where referral to secondary care must be considered.
- 'Indication for corticosteroid injection' for patients where a corticosteroid injection should be considered as the first-line treatment option.
- 'Indication for physical therapy management' for patients where physical therapy management is considered to be the first choice of treatment.
- 'Watchful waiting' for patients most likely to recover without specific treatment interferences or when no evidence or only level 5 evidence was available regarding the effectiveness of physical therapy and/or surgical intervention.

In case of disagreement, consensus was reached by discussion.

2.3. Inter-professional agreement study

2.3.1. Design

We conducted this inter-professional agreement study by secondary analysis of the findings from DMUS obtained in a previous study. The method of the original inter-professional agreement study is presented in a previous study and the main characteristics are summarized below (Thoomes-de Graaf et al., 2014).

2.3.2. PTs and radiologists

Dutch PTs trained in the use of DMUS were asked to participate. All participating PTs had at least one year of DMUS post-graduation experience, and performed more than 100 DMUS in this post-graduation period. In addition, the minimal requirement of their ultrasound system was a transducer frequency range of at least 5–10 MHz and a minimal feature of digital beamformer technology. Only experienced radiologists were recruited. Both were trained in a consensus meeting to use an international scanning protocol (Jacobson, 2011) and a standardized outcome form. All participating radiologists (9) and PTs (13) were male. PTs had a median five years of experience (interquartile range (IQR) 1.5–6), and all participating PTs made more than 100 ultrasounds of the shoulder (54% made more than 200 ultrasounds). The radiologists had a median of 10 years of experience (IQR 5-20) and they all made more than 200 ultrasounds of the shoulder (Thoomes-de Graaf et al., 2014).

2.3.3. Patients

Adult patients with shoulder pain were recruited from primary care physical therapy clinics. Patients were excluded in the presence of serious pathology (e.g. infection, cancer or fracture), previous surgery and/or if they received diagnostic imaging techniques of the shoulder such as MRI and diagnostic ultrasound in the previous three months. The mean age of patients was 56 years (Standard deviation (SD) 12) and 54% was male. Full characteristics of the 65 participating are presented in Table 1 (Thoomes-de Graaf et al., 2014).

Table 1
Characteristics of the patients.

Variable	Frequencies
Gender: N (%male)	35 (54%)
Age: Mean (SD)	56 (12)
Duration of complaints in weeks: Median (IQR)	12 (6-29)
Medication use: N (%yes)	31 (52%)
Pain Score[a]: Median (IQR)	6 (5-7)
SPADI[b]: Median (IQR)	51 (35-67)
SDQ[c]: Median (IQR)	71 (50-87)
EQ5D health status[d]: Median (IQR)	7 (6-8)

Data of the questionnaires of three patients missing.
Abbreviations: N, Number; SD, Standard deviation; IQR, Interquartile range.
[a] The pain score has been measured using the Numeric Rating Scale (NRS) ranging from 0 to 10, with 0 no pain and 10 worst pain ever.
[b] The Shoulder Pain and Disability Index (SPADI) ranges from 0 to 100, a higher score indicates a higher level of disability.
[c] The Shoulder Disability Questionnaire (SDQ) ranges from 0 to 100, a higher score indicating more severe disability.
[d] The Euroqol (EQ5D) health status ranges from 0 to 10, 0 represents the worst possible health status and 10 the best possible health status.

2.3.4. Measurement

Based on history taking and physical examination, the PT established an initial diagnostic hypothesis, and performed a DMUS if this was needed for the diagnostic work-up. Within one week, a second DMUS was performed by a radiologist, who only received the initial diagnostic hypothesis from the PT. Both the patient and radiologist were blinded for the DMUS diagnosis of the PT.

Diagnostic ultrasound diagnoses were standardized in terms of a total of 24 possible outcomes based on observed disorder (diagnostic outcome category) and affected tendon. We defined 10 primary diagnostic outcome categories: 1) tendinopathy, 2) calcification, 3) full thickness tear or 4) partial thickness tear, 5) biceps tendon tear, 6) subacromial-subdeltoid bursitis, 7) subacromial impingement, 8) osteoarthritis of the acromio-clavicular joint, 9) no pathology, or 10) other (eg. labral tear, capsular thickening). In case a diagnosis in category 1-4 was made, it was specified by adding the affected tendon; supraspinatus, subscapularis and infraspinatus/teres minor (Karel et al., 2013).

In the present study, based on our literature study on best evidence treatment policies per traditional diagnostic label, two authors (MTG, RO) categorized and recoded the 24 possible outcomes into the new four treatment related categories; 'referral to secondary care', 'indication for corticosteroid injection', 'indication for physical therapy management' and 'watchful waiting'. Patients could only be labeled with one treatment label; in case of multiple 'traditional' diagnoses, the patient was labeled according to the highest level of care needed. 'Referral to secondary care' was deemed to precede 'indication for corticosteroid injection', and 'indication for physical therapy management' preceded 'watchful waiting'.

2.3.5. Analysis

Each new treatment related category was dichotomized (patient labeled as possible indication for e.g. physical therapy or not), to be able to calculate observed agreement and kappa values plus 95% confidence interval (95%CI) for all treatment related categories. Besides, an overall kappa was calculated (with 95% CI) based upon all treatment related categories (Kottner et al., 2011; Sim and Wright, 2005).

For the interpretation of the kappa values, the following criteria were used: almost perfect (0.81–1.00), substantial (0.61–0.80), moderate (0.41–0.60), fair (0.21–0.40), slight (0.01–0.20) or poor (< 0.00) agreement (Landis and Koch, 1977; Viera and Garrett, 2005).

All statistical analyses were performed using IBM SPSS Statistics 25.0 software.

3. Results

3.1. Systematic overview of current evidence

A total of 706 articles were found based upon the original search. A search on primary studies was performed for the categories tendinopathy and lesion of the biceps tendon, partial thickness tendon tear and arthritis of the acromioclavicular (AC)-joint as no systematic reviews were found for these categories, and another 837 articles were retrieved. For both search strategies, see the appendix. After titles and abstracts were screened, a total of 85 were selected for assessment in full text. Papers were excluded if they did not meet our selection criteria (e.g. a diagnostic study, using plasma injections etc.). Finally, a total of 32 articles met our selection criteria for inclusion in this study; 21 systematic reviews, one level 4 study, and 10 level 5 studies (Fig. 1). Results of the AMSTAR 2 assessment are presented in Table 2. No other risk of bias tools were applicable.

Based on the available evidence of effectiveness of treatment, the traditional diagnostic labels were recoded into three new treatment related categories, as none of the traditional diagnostic labels was recoded into the 'indication for corticosteroid injection' as this was not a first-choice treatment option. There was no disagreement between both

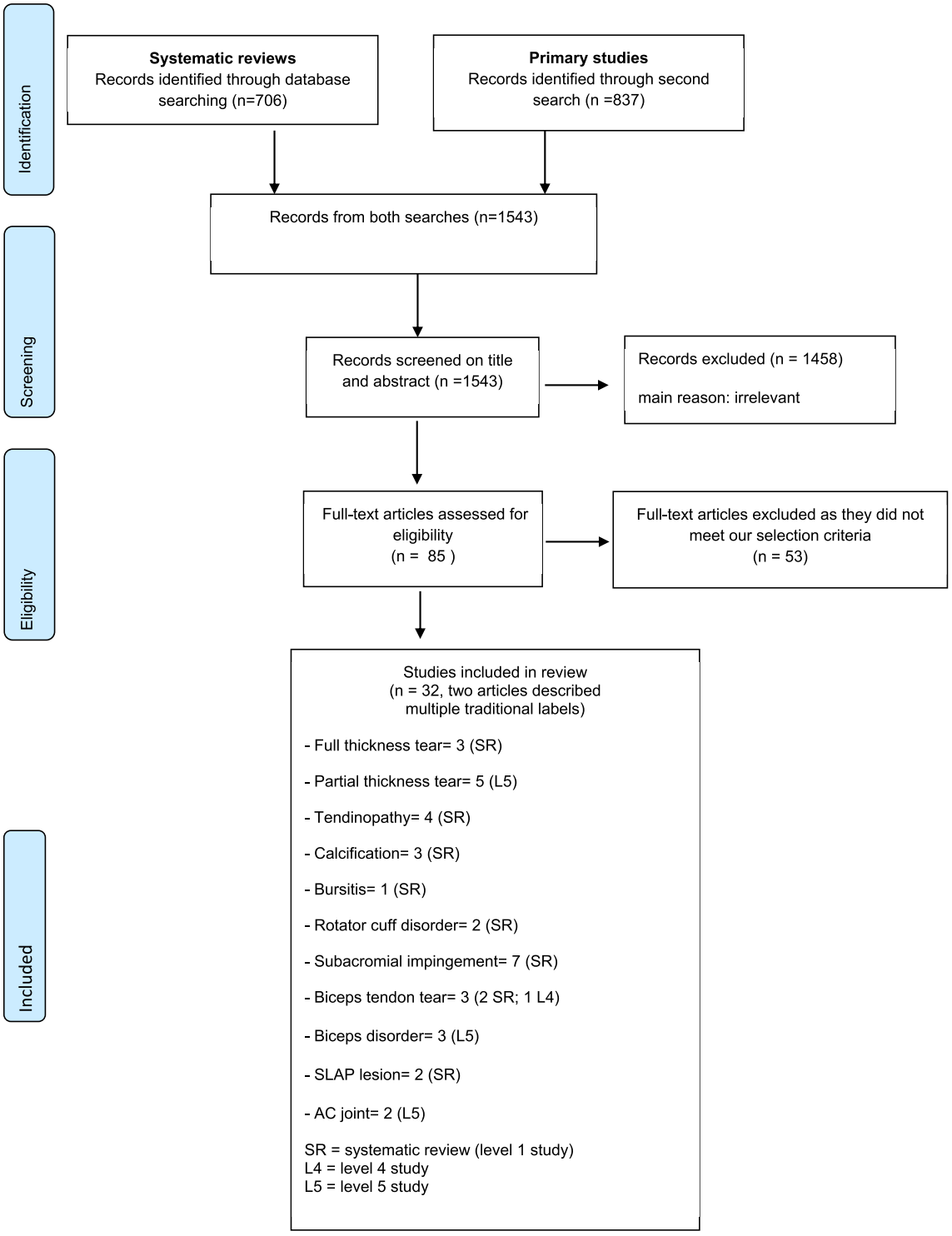

Fig. 1.

authors. The 'full thickness tear', 'biceps tendon tear' and 'SLAP- lesion' were recoded into the treatment related category: 'referral to secondary care', see Table 3. In this category, it is important that the patient is referred to a medical doctor to perform additional diagnostic tests and/or to discuss surgery. 'Calcification', 'tendinopathy' and 'partial tear' of the rotator cuff, 'subacromial impingement' and 'bursitis' were recoded into the category 'indication for physical therapy', see Table 4. All others ('arthritis/arthrosis of the AC-joint' and biceps disorders ('calcification' and 'tendinopathy' of the biceps) and 'no pathology') were recoded to 'watchful waiting', see Table 5.

3.2. Inter-professional agreement study

The prevalence of positive findings and kappa values per therapeutic category are reported in Table 6.

The overall kappa was 0.60 (95%CI 0.43–0.76), indicating the new treatment related categories showed moderate agreement between PTs and radiologists. There was substantial agreement within the new treatment related category 'referral to secondary care' (k = 0.74) and both new treatment related categories 'indication for physical therapy management' (k = 0.57) and 'watchful waiting' (k = 0.46) showed

Table 2
The AMSTAR 2 assessment.

Author	AMSTAR items																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Overall
Bannuru et al., 2014	Y	Y	Y	PY	Y	Y	N	Y	PY	N	NA	NA	Y	Y	NA	Y	Moderate
Boudreault et al., 2014	Y	N	Y	PY	Y	N	Y	PY	Y	N	Y	N	N	Y	N	Y	Low
Coghlan et al., 2008	Y	PY	Y	PY	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	Y	Moderate
Desjardins-Charbonneau et al., 2015	N	N	Y	PY	Y	N	N	PY	Y	N	Y	N	Y	N	N	Y	Moderate
Downie and Miller, 2012	Y	PY	Y	PY	Y	Y	N	N	N	N	NA	NA	Y	N	NA	Y	Low
Erickson et al., 2015	Y	N	Y	PY	N	N	N	PY	N	N	NA	NA	N	N	NA	Y	Critically low
Frost et al., 2009	Y	PY	Y	PY	N	Y	N	PY	N	N	NA	NA	Y	N	NA	Y	Low
Ge et al., 2015	Y	Y	Y	PY	Y	Y	N	PY	PY	N	N	N	Y	N	N	Y	Low
Gebremariam et al., 2011	Y	PY	Y	PY	Y	Y	N	PY	Y	N	NA	NA	Y	N	NA	Y	Moderate
Gorantla et al., 2010	Y	PY	Y	PY	Y	Y	N	PY	N	N	NA	NA	Y	N	NA	Y	Critically low
Green et al., 2003	Y	PY	Y	PY	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	High
Hanratty et al., 2012	Y	Y	Y	PY	N	N	N	PY	Y	N	Y	Y	Y	Y	Y	N	Moderate
Huisstede et al., 2011	Y	PY	Y	PY	Y	Y	Y	PY	Y	N	NA	NA	Y	N	NA	Y	Moderate
Kelly et al., 2010	Y	N	Y	PY	Y	Y	N	PY	Y	N	NA	NA	Y	Y	Y	N	Moderate
Kromer et al., 2009	Y	PY	Y	PY	N	Y	N	PY	Y	N	NA	NA	Y	N	NA	N	Moderate
Littlewood et al., 2012	N	Y	Y	Y	Y	Y	Y	Y	Y	N	NA	NA	Y	N	NA	Y	Moderate
Louwerens et al., 2014	N	N	Y	PY	Y	N	N	N	Y	N	Y	N	N	N	N	Y	Low
Mall et al., 2013	Y	PY	Y	PY	Y	N	N	PY	N	N	NA	NA	Y	N	NA	Y	Low
Page et al., 2016	Y	Y	Y	PY	Y	Y	N	PY	Y	Y	NA	NA	Y	Y	NA	Y	Moderate
Saltychev et al., 2015	Y	N	Y	PY	N	N	N	Y	Y	N	N	Y	Y	N	N	Y	Low
Toliopoulos et al., 2014	Y	N	Y	PY	Y	N	Y	PY	Y	N	NA	NA	N	N	Y	Y	Low

Abbreviations: Y, Yes; N, No; PY, Partial Yes; NA, Not applicable.
1. Components of PICO are included, 2. Protocol prior to the conduction and justification if deviated, 3. Selection criteria, 4. Literature search strategy, 5. Study selection in duplicate, 6. Data extraction in duplicate, 7. List of excluded studies and justification, 8. Description of included studies in detail, 9. Risk of bias assessment, 10. Report funding, 11. Appropriate methods for statistical combination of results, 12. Assessment of potential impact of risk of bias on results, 13. Account for risk of bias in interpreting results, 14. Discussion of heterogeneity, 15. Investigation of publication bias, 16. Report conflict of interest.

Table 3
Possible indications for referral to secondary care.

Diagnostic category	Evidence	Level of evidence CEBM
Full thickness tear	1) Moderate evidence that surgery more effective than physical therapy (exercise therapy) in the mid and long term. 2) Limited evidence that surgery may improve outcome in patients aged 60 years and older. 3) Inconsistent evidence regarding the timing of surgery.	1) Level 1: (Huisstede et al., 2011) 2) Level 2*: (Downie and Miller, 2012) 3) Level 1: (Huisstede et al., 2011) Level 2*: (Mall et al., 2013)
Biceps tendon tear (long head)	1) Surgical treatment showed better outcome on strength and days of sick leave compared to nonsurgical treatment but not on arm pain. 2) Regardless the type of surgery, improvement in postoperative outcomes was shown.	1) Level 4: (Mariani et al., 1988) 2) Level 2*: (Frost et al., 2009; Ge et al., 2015)
SLAP lesion	1) Limited evidence that an arthroscopic repair shows better outcomes for individuals not involved in throwing or overhead sports. 2) Limited evidence that surgery shows good outcomes in an older cohort of patients. 3) No evidence concerning conservative treatment of a SLAP-lesion.	1) Level 2*: (Gorantla et al., 2010) 2) Level 2*: (Erickson et al., 2015)

Level 1: systematic review, level 2*: downgraded systematic review, level 2: randomized clinical trial (RCT) or inception cohort study, level 4: Case series or case-control study.

moderate agreement. All treatment related categories showed high observed agreement (> 85%).

4. Discussion

The results of this study indicate that the agreement between the radiologist and PT was moderate to substantial in stratifying patients with shoulder pain into the new treatment related categories. It shows that there may be possibilities to use DMUS to classify patients into new treatment related categories. DMUS could help the PT in order to assess if a patient should be referred to secondary care or not as this new treatment related category showed the highest agreement. However, as this is just an explorative study, more research regarding this stratifying strategy using DMUS and treatment related categories, is needed in order to implement this into clinical care.

4.1. Comparison with the literature

The main intention of this paper is to explore new possibilities to breach decades of circular reasoning. Our aim was to explore a different type of clinical reasoning. As this type of research has not been performed before, we cannot compare our results with other studies. However, the agreement between radiologists and PTs using these new treatment related categories is higher than the agreement reported in our initial study using the traditional diagnostic labels. Disagreement in differentiating between a partial thickness tear and a tendinopathy or calcification has been mentioned before in the literature (Bianchi et al., 2005; Jamadar et al., 2010). With the new treatment related categories, these categories all belong to the same new label, namely 'indication for physical therapy', resulting in a higher agreement. The observed agreement in our study was higher than Cohen's Kappa, this is due to the fact that Cohen's κ adjusts for expected agreement (Cohen, 1960; Kottner et al., 2011) and is therefore a common observation.

4.2. Strength and limitations

The methodology of this paper is not flawless, which is a reflection of being explorative. For example, the radiologists and PTs were not informed about the use of DMUS in the way we have assessed it in this study, namely as a stratifying tool. Therefore, the outcome of a new

Table 4
Possible indication for physiotherapy management.

Diagnostic category	Evidence	Level of evidence CEBM
Rotator cuff disorder	1) Limited evidence that arthroscopic subacromial decompression shows no better results on differences on pain, function, active range of motion and strength or global treatment success compared to 'manual therapy and exercise'. 2) Limited evidence that manual therapy and exercise are equally effective (no clinically important differences between and exercise and glucocorticoid injection on pain, function, quality of life, night pain and active range of motion). 3) Limited evidence that corticosteroid injections show better results compared to physical therapy at short term only. However, corticosteroid injections are associated with an increased risk of facial flushing. 4) Limited evidence that there are no differences in effect between different conservative treatments. Mainly exercise and mobilization/manipulation have been evaluated.	1) Level 1: (Page et al., 2016) 2) Level 1: (Page et al., 2016) 3) Level 1: (Green et al., 2003) 4) Level 1: (Green et al., 2003)
Subacromial impingement	1) Moderate to strong evidence that surgery and physical therapy (physiotherapist-led exercises) are equally effective on either functional outcome scores or pain relief. Generally, surgical interventions are associated with more complications and higher costs than conservative treatment. 2) Limited evidence that corticosteroid injections shown positive results compared to physical therapy in the short term only. Injections were associated with adverse effects. 3) Limited evidence that physical therapy (mobilization, home-based strengthening exercises, strapping, advice on posture, and electrotherapy) is more effective than no treatment. 4) Moderate evidence that exercises plus manual therapy is more beneficial than exercises alone. 5) Moderate evidence for no differences between physiotherapy-led exercises or home-based exercises.	1) Level 1: (Coghlan et al., 2008; Gebremariam et al., 2011; Green et al., 2003; Kromer et al., 2009). Level 2*: (Saltychev et al., 2015). 2) Level 1: (Green et al., 2003) 3) Level 1: (Kelly et al., 2010; Kromer et al., 2009) 4) Level 1: (Kromer et al., 2009) 5) Level 1: (Hanratty et al., 2012)
Partial thickness tear solely	1) Several level 5 studies indicated that conservative management is the first line treatment and surgery is only indicated if conservative treatment has failed. No evidence concerning the effectiveness of conservative treatments in partial thickness tears solely.	1) Level 5: (Finnan and Crosby, 2010; Franceschi et al., 2011; Shin, 2011; Tashjian, 2012; Wolff et al., 2006)
Tendinopathy solely	1) Moderate evidence that surgery and physical therapy (supervised exercises) are equally effective. 2) Low to moderate evidence that oral NSAIDs and corticosteroids injections are equally effective in reducing pain or improving function in the short term. Inconsistent evidence concerning adverse event with corticosteroids injections. The review does not support the use of corticosteroid injections 3) Limited evidence that laser therapy showed better results compared to oral NSAIDs or placebo in reducing pain. 4) Moderate evidence that physical therapy (supervised as well as home-based exercises, incorporating a loading strategy) is effective in terms of pain and functional disability compared to no intervention and placebo. There is low to moderate evidence manual therapy can decrease pain; however, it is unclear whether it can improve function.	1) Level 1: (Littlewood et al., 2012) Level 2*: (Toliopoulos et al., 2014) 2) Level 2*: (Boudreault et al., 2014) 3) Level 2*: (Boudreault et al., 2014) 4) Level 1: (Desjardins-Charbonneau et al., 2015; Littlewood et al., 2012)
Calcification solely	1) Moderate evidence that surgery and conservative treatment (graded physical therapy strengthening program/physical therapy program of exercise and education/exercise program) are equally beneficial. Conservative treatment is preferred because of lower complication risks. 2) Moderate evidence that high-energy extracorporeal shockwave therapy (high-energy ESWT) is superior to placebo for chronic calcific tendinitis. 3) No evidence exists on the effectiveness of ESWT compared to physical therapy.	1) Level 1: (Gebremariam et al., 2011) 2) Level 1: (Bannuru et al., 2014) Level 2*: (Louwerens et al., 2014)
Bursitis solely	1) There were no adequate studies reporting the efficacy of therapies on bursitis.	1) Level 1: (Green et al., 2003)

Table 5
Watchful waiting.

Diagnostic category	Evidence	Level of evidence CEBM
Arthritis/osteoarthritis of the Acromioclavicular-joint	1) No evidence concerning the effectiveness of conservative treatments in osteoarthritis of the AC joint	1) Level 5: (Buttaci et al., 2004; Docimo et al., 2008)
Biceps disorder	1) No evidence concerning the effectiveness of conservative treatments in biceps disorders (tendinopathy and calcification). Several level V studies indicated treatment should begin with conservative treatment, but no data on effectiveness was presented	1) Level 5: (Khazzam et al., 2012; Nho et al., 2010; Snyder et al., 2012)
No specific pathology or not interpretable image	If "no pathologies" are found using diagnostic US, watchful waiting or monitoring is regarded	None. Clinical reasoning.

Level 1: systematic review, level 2*: downgraded systematic review, level 2: randomized clinical trial (RCT) or inception cohort study, level 5: Mechanism based reasoning or expert opinion.

treatment related category for a certain individual could have been different from recoding the traditional diagnostic label if we would have asked in this specific way. We have instructed PTs and radiologists to use the Jacobson protocol (Jacobson, 2011), it is unclear how it would impact the agreement if we had instructed them differently. In order to minimize progression bias, we chose a maximum period of one week between both tests. We assume that the conditions of interest did not change within this time frame. Another limitation might be the level of DMUS experience between radiologists and PTs, respectively median of 10 and five years. DMUS of the rotator cuff is considered to

Table 6
Results of agreement.

Category	Frequency	Cohen's kappa (95%CI)	Observed agreement
Overall		0.60 (0.43–0.76)	90%
Possible indication for surgery	PT: 8 Radiologist: 10 Both: 7	0.74 (0.50–0.99)	94%
Possible indication for physiotherapy management	PT: 53 Radiologist: 48 Both: 45	0.57 (0.33–0.82)	85%
Watchful waiting	PT: 4 Radiologist: 8 Both: 3	0.46 (0.04–0.87)	91%

be operator-dependent with its accuracy being related to the operator's level of experience. However, there is evidence that there is good to excellent agreement for the detection of rotator cuff tears, which only slightly improves with increasing experience (Alavekios et al., 2013; Murphy et al., 2013; Rutten et al., 2010).

Besides, as treatment related categories are being based upon current knowledge, these categories can evolve over time. For example, the traditional diagnostic labels 'bursitis' and 'partial thickness tear' were part of the label rotator cuff disorders/SAPS. Interestingly, there were no systematic reviews or RCTs included for a solitary 'bursitis' or 'partial thickness tear'. Moreover, several studies used a diagnostic label as an umbrella term, e.g. 'tendinopathy' encompassing all rotator cuff disorders instead of only tendinopathy (Desjardins-Charbonneau et al., 2015; Toliopoulos et al., 2014). To be transparent, we reported the original reported traditional diagnostic labels. We therefore chose to combine these traditional labels, as it is difficult to draw conclusions on any traditional diagnostic label separately.

4.3. Implications for clinical practice

At the moment, our findings cannot be implemented into clinical care. In the future, DMUS might be of additional value at first consultation in order to facilitate PTs in making treatment- or referral decisions. PTs could potentially use DMUS to help them stratify patients into the new treatment related categories using the following interpretations: 1. It seems like a rotator cuff or biceps tendon is disrupted (implication for referral to secondary care), 2. It seems like there is something different than expected when compared to a "normal" structure in the rotator cuff and subacromial region but it does not seem disrupted (implication physical therapy management), 3. There is nothing unusual on the image or there is something different than expected on a healthy subject in the AC or biceps region (indication for watchful waiting).

Usual physical therapy assessment includes the assessment of functional limitations (range of motion, strength etc.) related to the needs of the patient, which seems to be appropriate as both exercises and mobilization seem to be the main interventions in the entire physical therapy group. Therefore, patients categorized into the 'watchful waiting' category by DMUS (as there were no unusual findings seen), could eventually still be treated by the PT, as functional limitations could be an indication for physical therapy. Therefore, DMUS should only be considered as an add-on test. Moreover, DMUS findings should always be placed in the clinical context based on history taking and physical examination. DMUS can support the PT to establish treatment- and referral decisions. Therefore, DMUS should only be considered as an add-on test. Moreover, DMUS findings should always be placed in the clinical context based on history taking and physical examination. DMUS can support the PT to establish treatment- and referral decisions.

Despite the DMUS findings at the start of treatment, it is of great importance to be aware of the clinical course of a patient with shoulder pain. When a patient does not recover within 6–12 weeks, a referral to the general practitioner (GP) is advised (Jansen et al., 2011). Not only because the results of the DMUS might not be completely accurate, but also stratifying patients into the category 'indication for physical therapy', is based upon the first treatment choice. If conservative physical therapy fails, the patient should be seen by the GP, and treated according to their guidelines. For example, a corticosteroid injection or referral to secondary care might then be indicated (Winters et al., 2008). Even though physical therapy and a corticosteroid injection were as effective in the category 'rotator cuff disorders', a corticosteroid injection was not rated as a first choice of treatment in this study, as corticosteroids were associated with higher adverse event rates. A corticosteroid injection could still be a useful second-choice treatment option in stepped care policy. Care providers have to make their own decisions regarding the risks and benefits (Stanhope et al., 2012).

When starting treatment, PTs should also consider possible psychosocial prognostic factors, as these prognostic factors might affect treatment outcome. Moreover, PTs should be aware that observed rotator cuff disorders using DMUS could be asymptomatic (Louwerens et al., 2015; Milgrom et al., 1995). To prevent unnecessary treatment of asymptomatic pathology, the observed findings have to be linked to medical history and physical examination. Furthermore, besides screening for red flags, abnormal scan findings when using DMUS could be an indication to consult the GP (e.g. neoplasm), although these findings are extremely rare.

Future research should be focused on assessing the inter-professional agreement between radiologists and other caregivers using DMUS (e.g. PTs and GPs) using DMUS and treatment related categories with the concordant instructions. Moreover, it would be interesting to assess whether this stratification indeed impacts the clinical pathway of patients and therefore impacts the outcome of the therapeutic process (and cost-effectiveness, e.g. return to work).

This study is approved by the Medical Ethical Committee.

Appendix. Search

EMBASE: (('shoulder injury'/de OR 'shoulder impingement syndrome'/de OR 'rotator cuff injury'/exp OR (((shoulder* OR 'rotator cuff' OR subacromial OR biceps) NEAR/3 (bursitis OR syndrome OR injur* OR impingement* OR disorder*))):ab,ti OR (Shoulder/de OR 'biceps brachii muscle'/de OR 'rotator cuff'/de OR 'acromioclavicular joint'/de OR (shoulder* OR labrum OR labral):ab,ti) AND (Tendinitis/de OR Calcification/de OR rupture/de OR 'tendon rupture'/de OR 'ligament lesion'/de OR 'tendon lesion'/de OR atrophy/de OR arthritis/de OR osteoarthritis/de OR (Tendinitis OR Tendinopath* OR Calcificat* OR rupture* OR lesion OR tear* OR atroph* OR arthrit* OR osteoarthrit*):ab,ti))) AND ('evidence based medicine'/de OR 'meta analysis'/de OR 'systematic review'/de OR ('evidence based' OR 'meta analysis' OR 'systematic review'):ab,ti) AND (therapy/exp OR 'treatment outcome'/exp OR therapy:lnk OR (therap* OR treat*):ab,ti).

COCHRANE: (((((shoulder* OR 'rotator cuff' OR subacromial OR biceps) NEAR/3 (bursitis OR syndrome OR injur* OR impingement* OR disorder*))):ab,ti OR ((shoulder* OR labrum OR labral):ab,ti) AND ((Tendinitis OR Tendinopath* OR Calcificat* OR rupture* OR lesion OR tear* OR atroph* OR arthrit* OR osteoarthrit*):ab,ti))) AND ((therap* OR treat*):ab,ti).

EMBASE: (Shoulder/de 'shoulder injury'/de OR 'biceps brachii muscle'/de OR 'acromioclavicular joint'/de OR (shoulder* OR labrum OR labral OR biceps OR acromioclavicul*):ab,ti) AND (Tendinitis/de OR Calcification/de OR rupture/de OR 'tendon rupture'/de OR 'ligament lesion'/de OR 'tendon lesion'/de OR arthritis/de OR osteoarthritis/de OR (Tendinitis OR Tendinopath* OR Calcificat* OR rupture* OR lesion OR tear* OR atroph* OR arthrit* OR osteoarthrit*):ab,ti) AND (therapy/exp OR 'treatment outcome'/exp OR therapy:lnk OR surgery:lnk OR (therap* OR treatment* OR repair* OR surg* OR

operat*):ab,ti) AND ('controlled clinical trial'/exp OR (((control*) NEAR/3 (trial*)) OR random* OR ((double OR single) NEAR/3 blind*)):ab,ti).

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References

Alavekios, D.A., Dionysian, E., Sodl, J., Contreras, R., Cho, Y., Yian, E.H., 2013. Longitudinal analysis of effects of operator experience on accuracy for ultrasound detection of supraspinatus tears. J. Shoulder Elbow Surg./Am. Shoulder Elb. Surg. 22, 375–380.

Bannuru, R.R., Flavin, N.E., Vaysbrot, E., Harvey, W., McAlindon, T., 2014. High-energy extracorporeal shock-wave therapy for treating chronic calcific tendinitis of the shoulder: a systematic review. Ann. Intern. Med. 160, 542–549.

Beaudreuil, J., Nizard, R., Thomas, T., Peyre, M., Liotard, J.P., Boileau, P., et al., 2009. Contribution of clinical tests to the diagnosis of rotator cuff disease: a systematic literature review. Joint Bone Spine 76, 15–19.

Bianchi, S., Martinoli, C., Abdelwahab, I.F., 2005. Ultrasound of tendon tears. Part 1: general considerations and upper extremity. Skeletal Radiol. 34, 500–512.

Bier, J.D., Scholten-Peeters, W.G.M., Staal, J.B., Pool, J., van Tulder, M.W., Beekman, E., et al., 2018. Clinical practice guideline for physical therapy assessment and treatment in patients with nonspecific neck pain. Phys. Ther. 98, 162–171.

Boudreault, J., Desmeules, F., Roy, J.S., Dionne, C., Fremont, P., Macdermid, J.C., 2014. The efficacy of oral non-steroidal anti-inflammatory drugs for rotator cuff tendinopathy: a systematic review and meta-analysis. J. Rehabil. Med. 46, 294–306.

Buttaci, C.J., Stitik, T.P., Yonclas, P.P., Foye, P.M., 2004. Osteoarthritis of the acromioclavicular joint: a review of anatomy, biomechanics, diagnosis, and treatment. Am. J. Phys. Med. Rehab./Assoc. Acad. Physiatr. 83, 791–797.

Campbell, M., 2016. Problems with large joints: shoulder conditions. FP Essent. 446, 25–30.

Coghlan, J.A., Buchbinder, R., Green, S., Johnston, R.V., Bell, S.N., 2008. Surgery for rotator cuff disease. Cochrane Database Syst. Rev. 23 (1) CD005619.

Cohen, J., 1960. A coefficient of agreement for nominal scales. Educ. Psychol. Meas. 20, 37–46.

Desjardins-Charbonneau, A., Roy, J.S., Dionne, C.E., Frémont, P., MacDermid, J.C., Desmeules, F., 2015. The efficacy of manual therapy for rotator cuff tendinopathy: a systematic review and meta-analysis. J. Orthop. Sports Phys. Ther. 45, 330–350.

Diercks, R., Bron, C., Dorrestijn, O., Meskers, C., Naber, R., de Ruiter, T., et al., 2014. Guideline for diagnosis and treatment of subacromial pain syndrome: a multidisciplinary review by the Dutch orthopaedic association. Acta Orthop. 85, 314–322.

Docimo Jr., S., Kornitsky, D., Futterman, B., Elkowitz, D.E., 2008. Surgical treatment for acromioclavicular joint osteoarthritis: patient selection, surgical options, complications, and outcome. Curr. Rev. Musculoskelet. Med. 1, 154–160.

Downie, B.K., Miller, B.S., 2012. Treatment of rotator cuff tears in older individuals: a systematic review. J. Shoulder Elbow Surg./Am. Shoulder Elb. Surg. [et al] 21, 1255–1261.

Erickson, J., Lavery, K., Monica, J., Gatt, C., Dhawan, A., 2015. Surgical treatment of symptomatic superior labrum anterior-posterior tears in patients older than 40 years: a systematic review. Am. J. Sports Med. 43, 1274–1282.

Finnan, R.P., Crosby, L.A., 2010. Partial-thickness rotator cuff tears. J. Shoulder Elbow Surg./Am. Shoulder Elb. Surg. [et al] 19, 609–616.

Franceschi, F., Papalia, R., Del Buono, A., Maffulli, N., Denaro, V., 2011. Repair of partial tears of the rotator cuff. Sports Med. Arthrosc. Rev. 19, 401–408.

Frost, A., Zafar, M.S., Maffulli, N., 2009. Tenotomy versus tenodesis in the management of pathologic lesions of the tendon of the long head of the biceps brachii. Am. J. Sports Med. 37, 828–833.

Ge, H., Zhang, Q., Sun, Y., Li, J., Sun, L., Cheng, B., 2015. Tenotomy or tenodesis for the long head of biceps lesions in shoulders3/28/2015 6:11:18 PMA systematic review and meta-analysis. PLoS One 10.

Gebremariam, L., Hay, E.M., Koes, B.W., Huisstede, B.M., 2011. Effectiveness of surgical and postsurgical interventions for the subacromial impingement syndrome: a systematic review. Arch. Phys. Med. Rehabil. 92, 1900–1913.

Gorantla, K., Gill, C., Wright, R.W., 2010. The outcome of type II SLAP repair: a systematic review. Arthrosc. J. Arthrosc. Relat. Surg. Off. Publ. Arthrosc. Assoc. North Am. Int. Arthrosc. Assoc. 26, 537–545.

Green, S., Buchbinder, R., Hetrick, S., 2003. Physiotherapy interventions for shoulder pain. Cochrane Database Syst. Rev. CD004258.

Greving, K., Dorrestijn, O., Winters, J.C., Groenhof, F., van der Meer, K., Stevens, M., et al., 2012. Incidence, prevalence, and consultation rates of shoulder complaints in general practice. Scand. J. Rheumatol. 41, 150–155.

Hanratty, C.E., McVeigh, J.G., Kerr, D.P., Basford, J.R., Finch, M.B., Pendleton, A., et al., 2012. The effectiveness of physiotherapy exercises in subacromial impingement syndrome: a systematic review and meta-analysis. Semin. Arthritis Rheum. 42, 297–316.

Hegedus, E.J., Goode, A., Campbell, S., Morin, A., Tamaddoni, M., Moorman 3rd, C.T., et al., 2008. Physical examination tests of the shoulder: a systematic review with meta-analysis of individual tests. Br. J. Sports Med. 42, 80–92 (discussion).

Hill, J., Whitehurst, D.G., Lewis, M., Bryan, S., Dunn, K.M., Foster, N.E., et al., 2011;Oct 29. Comparison of stratified primary care management for low back pain with current best practice (STarT Back): a randomised controlled trial. Lancet 378, 1560–1571.

Howick J, Chalmers I, Glasziou P, Greenhalgh T, Heneghan C, Liberati A, et al. "The Oxford 2011 Levels of Evidence". Oxford Centre for Evidence-Based Medicine http://wwwcebmnet/indexaspx?o=5653. 2011.

Hughes, P.C., Taylor, N.F., Green, R.A., 2008. Most clinical tests cannot accurately diagnose rotator cuff pathology: a systematic review. Aust. J. Physiother. 54, 159–170.

Huisstede, B.M., Bierma-Zeinstra, S.M., Koes, B.W., Verhaar, J.A., 2006. Incidence and prevalence of upper-extremity musculoskeletal disorders. A systematic appraisal of the literature. BMC Muscoskelet. Disord. 7, 7.

Huisstede, B.M., Koes, B.W., Gebremariam, L., Keijsers, E., Verhaar, J.A., 2011. Current evidence for effectiveness of interventions to treat rotator cuff tears. Man. Ther. 16, 217–230.

Jacobson, J.A., 2011. Shoulder US: anatomy, technique, and scanning pitfalls. Radiology 260, 6–16.

Jamadar, D.A., Robertson, B.L., Jacobson, J.A., Girish, G., Sabb, B.J., Jiang, Y., et al., 2010. Musculoskeletal sonography: important imaging pitfalls. AJR Am. J. Roentgenol. 194, 216–225.

Jansen, M.J., Brooijmans, F., Geraets, J.J.X.R., Lenssen, A.F., Ottenheijm, R.P.G., PLI, F., et al., 2011. KNGF evidence statement subacromiale klachten. Ned. Tijdschr. Fysiother. 121.

Karel, Y., Scholten-Peeters, G.G.M., Thoomes-de Graaf, M., Duijn, E., van Broekhoven, J.B., Koes, B.W., et al., 2017. Physiotherapy for patients with shoulder pain in primary care: a descriptive study of diagnostic- and therapeutic management. Physiotherapy 103, 369–378.

Karel, Y.H., Scholten-Peeters, W.G., Thoomes-de Graaf, M., Duijn, E., Ottenheijm, R.P., Koes, B.W., et al., 2013. Current management and prognostic factors in physiotherapy practice for patients with shoulder pain: design of a prospective cohort study. BMC Muscoskelet. Disord. 14, 62.

Karel, Y.H., Verhagen, A.P., Thoomes-de Graaf, M., Duijn, E., van den Borne, M.P., Beumer, A., et al., 2016. Development of a prognostic model for patients with shoulder complaints in physiotherapy. Phys. Ther. 97 (1), 72–80.

Kelly, S.M., Wrightson, P.A., Meads, C.A., 2010. Clinical outcomes of exercise in the management of subacromial impingement syndrome: a systematic review. Clin. Rehabil. 24, 99–109.

Khazzam, M., George, M.S., Churchill, R.S., Kuhn, J.E., 2012. Disorders of the long head of biceps tendon. J. Shoulder Elbow Surg./Am. Shoulder Elb. Surg. [et al] 21, 136–145.

Koes, B.W., van Tulder, M., Lin, C.W., Macedo, L.G., McAuley, J., Maher, C., 2010. An updated overview of clinical guidelines for the management of non-specific low back pain in primary care. Eur. Spine J. Off. publ. Eur. Spine Soc. Eur. Spinal Deform. Soc. Eur. Sect. Cerv. Spine Res. Soc. 19, 2075–2094.

Kottner, J., Audige, L., Brorson, S., Donner, A., Gajewski, B.J., Hrobjartsson, A., et al., 2011. Guidelines for reporting reliability and agreement studies (GRRAS) were proposed. Int. J. Nurs. Stud. 48, 661–671.

Kromer, T.O., Tautenhahn, U.G., de Bie, R.A., Staal, J.B., Bastiaenen, C.H., 2009. Effects of physiotherapy in patients with shoulder impingement syndrome: a systematic review of the literature. J. Rehabil. Med. 41, 870–880.

Landis, J.R., Koch, G.G., 1977. The measurement of observer agreement for categorical data. Biometrics 33, 159–174.

Linsell, L., Dawson, J., Zondervan, K., Rose, P., Randall, T., Fitzpatrick, R., et al., 2006. Prevalence and incidence of adults consulting for shoulder conditions in UK primary care; patterns of diagnosis and referral. Rheumatology (Oxf., Engl.) 45, 215–221.

Littlewood, C., Ashton, J., Chance-Larsen, K., May, S., Sturrock, B., 2012. Exercise for rotator cuff tendinopathy: a systematic review. Physiotherapy 98, 101–109.

Lord, S.J., Staub, L.P., Bossuyt, P.M., Irwig, L.M., 2011. Target practice: choosing target conditions for test accuracy studies that are relevant to clinical practice. BMJ (Clin. Res. Ed.) 343, d4684.

Louwerens, J.K., Sierevelt, I.N., van Hove, R.P., van den Bekerom, M.P., van Noort, A., 2015. Prevalence of calcific deposits within the rotator cuff tendons in adults with and without subacromial pain syndrome: clinical and radiologic analysis of 1219 patients. J. Shoulder Elbow Surg./Am. Shoulder Elb. Surg. [et al] 24, 1588–1593.

Louwerens, J.K.G., Sierevelt, I.N., van Noort, A., van den Bekerom, M.P.J., 2014. Evidence for minimally invasive therapies in the management of chronic calcific tendinopathy of the rotator cuff: a systematic review and meta-analysis. J. Shoulder Elbow Surg. 23, 1240–1249.

Mall, N.A., Lee, A.S., Chahal, J., Sherman, S.L., Romeo, A.A., Verma, N.N., et al., 2013. An evidenced-based examination of the epidemiology and outcomes of traumatic rotator cuff tears. Arthrosc. J. Arthrosc. Relat. Surg. Off. Publ. Arthrosc. Assoc. North Am. Int. Arthrosc. Assoc. 29, 366–376.

Mariani, E.M., Cofield, R.H., Askew, L.J., Li, G.P., Chao, E.Y., 1988. Rupture of the tendon of the long head of the biceps brachii. Surgical versus nonsurgical treatment. Clin. Orthop. Relat. Res. 233–239.

McKiernan, S., Chiarelli, P., Warren-Forward, H., 2010. Diagnostic ultrasound use in physiotherapy, emergency medicine, and anaesthesiology. Radiography 16, 154–159.

Milgrom, C., Schaffler, M., Gilbert, S., van Holsbeeck, M., 1995. Rotator-cuff changes in asymptomatic adults. The effect of age, hand dominance and gender. J. Bone Joint Surg. Br. 77, 296–298.

Murphy, R.J., Daines, M.T., Carr, A.J., Rees, J.L., 2013. An independent learning method for orthopaedic surgeons performing shoulder ultrasound to identify full-thickness tears of the rotator cuff. J. Bone Joint Surg. Am 95, 266–272.

Nho, S.J., Strauss, E.J., Lenart, B.A., Provencher, M.T., Mazzocca, A.D., Verma, N.N., et al., 2010. Long head of the biceps tendinopathy: diagnosis and management. J. Am. Acad. Orthop. Surg. 18, 645–656.

Page, M.J., Green, S., McBain, B., Surace, S.J., Deitch, J., Lyttle, N., et al., 2016. Manual therapy and exercise for rotator cuff disease. Cochrane Database Syst. Rev. CD012224.
Rutten, M.J., Jager, G.J., Kiemeney, L.A., 2010. Ultrasound detection of rotator cuff tears: observer agreement related to increasing experience. AJR Am. J. Roentgenol. 195, W440–W446.
Saltychev, M., Aarimaa, V., Virolainen, P., Laimi, K., 2015. Conservative treatment or surgery for shoulder impingement: systematic review and meta-analysis. Disabil. Rehabil. 37, 1–8.
Schellingerhout, J.M., Verhagen, A.P., Thomas, S., Koes, B.W., 2008. Lack of uniformity in diagnostic labeling of shoulder pain: time for a different approach. Man. Ther. 13, 478–483.
Shea, B.J., Reeves, B.C., Wells, G., Thuku, M., Hamel, C., Moran, J., et al., 2017. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. BMJ (Clin. Res. Ed.) 358, j4008.
Shin, K.M., 2011. Partial-thickness rotator cuff tears. Kor. J. Pain 24, 69–73.
Sim, J., Wright, C.C., 2005. The kappa statistic in reliability studies: use, interpretation, and sample size requirements. Phys. Ther. 85, 257–268.
Snyder, G.M., Mair, S.D., Lattermann, C., 2012. Tendinopathy of the long head of the biceps. Med. Sport Sci. 57, 76–89.
Stanhope, J., Grimmer-Somers, K., Milanese, S., Kumar, S., Morris, J., 2012. Extended scope physiotherapy roles for orthopedic outpatients: an update systematic review of the literature. J. Multidiscip. Healthc. 5, 37–45.
Tashjian, R.Z., 2012. Epidemiology, natural history, and indications for treatment of rotator cuff tears. Clin. Sports Med. 31, 589–604.
Thoomes-de Graaf, M., Scholten-Peeters, G.G., Duijn, E., Karel, Y.H., van den Borne, M.P., Beumer, A., et al., 2014. Inter-professional agreement of ultrasound-based diagnoses in patients with shoulder pain between physical therapists and radiologists in The Netherlands. Man. Ther. 19, 478–483.
Toliopoulos, P., Desmeules, F., Boudreault, J., Roy, J.S., Frémont, P., MacDermid, J.C., et al., 2014. Efficacy of surgery for rotator cuff tendinopathy: a systematic review. Clin. Rheumatol. 33 (10), 1373–1383.
Viera, A.J., Garrett, J.M., 2005. Understanding interobserver agreement: the kappa statistic. Fam. Med. 37, 360–363.
Winters, J.C., Van der Windt, D.A.W.M., Spinnewijn, W.E.M., De Jongh, A.C., Van der Heijden, G.J.M.G., Buis, P.A.J., et al., 2008. NHG-standaard schouderklachten (Tweede herziening). Huisarts Wet. 51 (11), 555–565.
Wolff, A.B., Sethi, P., Sutton, K.M., Covey, A.S., Magit, D.P., Medvecky, M., 2006. Partial-thickness rotator cuff tears. J. Am. Acad. Orthop. Surg. 14, 715–725.